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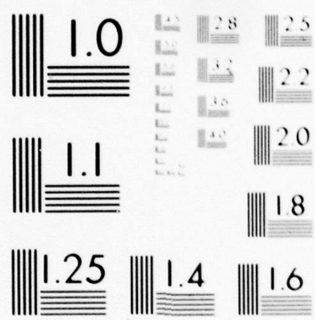

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CONFIDENCE LIMITS ON MTBF FOR SEQUENTIAL
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CONFIDENCE LIMITS ON MTBF FOR SEQUENTIAL TEST PLANS OF MIL-STD 781

by

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ABSTRACT

This paper presents tables for confidence limits on the MTBF of an exponential distribution using observations from sequential tests of MIL-STD 781. An example shows the use of the tables. The theory and calculation of the tables are explained in the Appendices.

Key Words: Exponential Distribution, Sequential Testing, Sequential Estimation

1. INTRODUCTION

MIL-STD 781 consists of a series of test plans for the mean time to equipment failure assuming an exponential distribution for the time to failure. In the (not yet approved) C-version of MIL-STD 781 [11] sequential plans are numbered I to VIII and the fixed-length plans are numbered IX to XVI. Plan XVII, an all equipment production reliability acceptance test, is not considered here. The advantages of sequential plans over fixed-length plans are savings in test time and money at no increase in risks.

The test plans accept with a high probability ($1-\alpha$) equipment with a mean time between failures MTBF = θ_0, the "design MTBF," whereas they accept with a small probability β equipment with a MTBF = θ_1, the "low-limit MTBF," where $\theta_1 < \theta_0$. Frequently, α is referred to as the producer's risk and β as the consumer's risk; $d = \theta_0/\theta_1$ is the design ratio. The tabulated plans of MIL-STD 781 are for various combinations $\alpha = \beta = .1$, .2, .3 and the design ratios d = 1.5, 2., 3.

The sequential test plans are based on the Sequential Probability Ratio Test of Wald [15] and the theory of Epstein and Sobel [7], but are truncated to avoid the (small) probability

of long test times. Exact properties are given by Epstein et al. [6] and Aroian [1]. Previous revisions of MIL-STD 781 (A and B) are discussed by Neathammer et al. [13]. Harter and Moore [9] investigate the effects of failure to meet the assumption of an exponential distribution.

Once equipment has been accepted or rejected it is often desirable to find confidence limits on the true MTBF. Estimation procedures for fixed-length tests are well-known and are discussed by Epstein [5] and Mann et al. [10]. Various attempts have been made at estimating the MTBF after a decision has been reached in a sequential test; see, for example, Aroian [3], Aroian et al. [4], and Sumerlin [14]. For various reasons, these approaches are not quite satisfactory.

In section 2 we present and explain new tables for obtaining confidence limits on the MTBF after termination of a sequential test using MIL-STD 781. A summary of the notation is given in Appendix I. The underlying theory and the methods of computation are given in Appendices II and III.

2. CONFIDENCE LIMITS FOR SEQUENTIAL TEST PLANS

This section briefly describes the sequential test plans of MIL-STD 781 [11]. Then it presents the tables of confidence limits on the true MTBF and shows how to use them. Acceptance can occur only at discrete times, whereas rejection can occur

at any time as soon as a required number of failures occur. Confidence limits after acceptance and rejection have to be treated separately.

2.1 Test Regions

Revision C of MIL-STD 781 [11] specifies eight sequential test plans (I-VIII) for various combinations of designated risks $\alpha = \beta = .1, .2, .3$ and design ratios $d = 1.5, 2., 3$. The true risks α' and β' are slightly different from the designated ones and are given in Table C-2 of the standard.

The accept and reject lines of the regions, as developed by Epstein and Sobel [7], are truncated to limit the total duration of a test. Exact properties of each region can be found by using the direct method of Aroian [1,2].

We define t_{Ai} as the standardized acceptance time, so that we accept equipment if not more than i failures occur in $t_{Ai}\theta_1$ hours; t_{Ri} as the standardized rejection time, so that we reject equipment if at least i failures occur at or before $t_{Ri}\theta_1$ hours. Together, t_{Ai} and t_{Ri} are the standard termination times. The actual termination times are obtained by multiplying the standard termination times by θ_1. (The standard low-limit MTBF is assumed to equal 1.)

2.2 Confidence Limits at Acceptance

Table 1 presents conservative $(1-\gamma)100\%$ standardized lower confidence limits $\underset{\sim}{\theta}_{\gamma,i}$ and $(1-\gamma)100\%$ standardized upper confidence limits $\tilde{\theta}_{\gamma,i}$ on the MTBF for all tests terminated by an

accept decision using Test Plans I-VIII for $\gamma = .5, .3, .2, .1, .05$. A conservative two-sided $(1-2\gamma)100\%$ standardized confidence interval is $\langle \underset{\sim}{\theta}_{\gamma,i}, \tilde{\theta}_{\gamma,i} \rangle$. Actual limits and intervals are obtained by multiplying $\underset{\sim}{\theta}_{\gamma,i}$ and $\tilde{\theta}_{\gamma,i}$ by the low limit MTBF θ_1. The derivation and computation of these tables is explained in the Appendices.

Example: Aircraft Black Box Item

Neathammer et al. [13] describe a production reliability acceptance test of a black box item for an aircraft. Using the revised terminology and requirements of MIL-STD 781-C, the problem can be stated as follows:

The consumer agrees to accept a monthly production lot of 40 units with probability $1-\alpha = .8$, if the true MTBF $\theta_0 = 100$ hours and will reject the lot with probability $1-\beta = .8$, if the true MTBF $\theta_1 = 50$ hours. The designated risks are thus $\alpha = \beta = .2$, the design ratio $d = 100/50 = 2$. Consequently Test Plan IV must be used. The required minimum sample size is 3 units.

The lot is accepted with

i. 0 failures after $t_{A0}\theta_1 = 2.8 \times 50$ hours = 140 hours,

ii. 1 failure after $t_{A1}\theta_1 = 4.18 \times 50$ hours = 209 hours,

and so on, where $t_{A0} = 2.8$, $t_{A1} = 4.18$, etc., are the standardized acceptance times. Assume in an actual test, relevant failures occurred at 50, 90, 120, 250, and 390 hours of

accumulated test time. The total accumulated times immediately after 1, 2, 3, 4 and 5 failures do not lead to rejection and the lot is accepted with 5 failures after 9.74 × 50 hours = 487 hours total test time ($t_{A5} = 9.74$).

Suppose now an 80% lower confidence limit on the MTBF is desired. First we find the conservative 80% standardized lower confidence limit $\underset{\sim}{\theta}_{.2,5} = 1.0459$ from the appropriate entry for Test Plan IV in Table I for $\gamma = .2$ and 5 failures. A conservative 80% lower confidence limit on the MTBF is 1.0459 × 50 = 52.3 hours.

Similarly, a conservative 80% upper confidence limit on the MTBF is 2.5225 × 50 = 126.1 hours, using $\tilde{\theta}_{.2,5} = 2.5225$.

Finally, a conservative 60% confidence interval on the MTBF is 52.3 to 126.1 hours.

2.3 Confidence Limits at Rejection

Table II presents exact $(1-\gamma)100\%$ standardized lower confidence limits $\underset{\sim}{\theta}_{\gamma,t}$ and $(1-\gamma)100\%$ standardized upper confidence limits $\tilde{\theta}_{\gamma,t}$ on the MTBF for Test Plans I-VIII terminated by a reject decision for selected values of the standardized time t and $\gamma = .5, .3, .2, .1, .05$. The derivation and computation of these tables is explained in the Appendices.

A test may be terminated by a reject decision at any time t, once a required number of failures have occurred. Thus it is impossible to tabulate confidence limits for all possible outcomes.

We use linear interpolation for nontabulated values of t, or in special cases use the χ^2-distribution for exact limits. In particular, say rejection of equipment occurs after $t\theta_1$ hours of total test time. If t exceeds the smallest value in Table II, the $(1-\gamma)100\%$ lower confidence limit can be calculated as follows:

i. From Table II we obtain $\underset{\sim}{\theta}_{\gamma,[t1]}$ and $\underset{\sim}{\theta}_{\gamma,[t2]}$, such that $[t1] < t < [t2]$ and [t1] is the largest tabled time less than t and [t2] is the smallest tabled time greater than t.

ii. Find

$$\underset{\sim}{\theta}_{\gamma,t} = \underset{\sim}{\theta}_{\gamma,[t1]} + (\underset{\sim}{\theta}_{\gamma,[t2]} - \underset{\sim}{\theta}_{\gamma,[t1]})\frac{t-[t1]}{[t2]-[t1]} \qquad (1)$$

iii. The actual $(1-\gamma)100\%$ lower confidence limit on the MTBF based on a rejection after $t\theta_1$ hours is then $\underset{\sim}{\theta}_{\gamma,t} \times \theta_1$.

If t is smaller than the smallest value in Table II we use the well-known relationship between the χ^2 and the Poisson distributions to calculate the $(1-\gamma)100\%$ standardized lower confidence limit on the MTBF as follows:

$$\underset{\sim}{\theta}_{\gamma,t} = 2t/\chi^2_{1-\gamma,2i} \qquad (2)$$

where $\chi^2_{1-\gamma,2i}$ is the $(1-\gamma)100$ percentile of the χ^2-distribution with 2i degrees of freedom, and i is the number of failures which lead to rejection at time $t\theta_1$. Harter [8] gives all necessary percentiles to complete the calculation of confidence limits in Table II.

Similarly we calculate a $(1-\gamma)100\%$ upper confidence limit, $\tilde{\theta}_{\gamma,t} \times \theta_1$, on MTBF by interpolation if t exceeds the smallest value in Table II.

If t is smaller than the smallest value in Table II we use

$$\tilde{\theta}_{\gamma,t} = 2t/\chi^2_{\gamma,2i} \tag{3}$$

where $\chi^2_{\gamma,2i}$ is the $\gamma 100$-th percentile of the χ^2-distribution with 2i degrees of freedom.

A $(1-2\gamma)100\%$ confidence interval on the MTBF for a test terminated by rejection after $t\theta_1$ hours is $\langle \theta_1 \underset{\sim}{\theta}_{\gamma,t}, \theta_1 \tilde{\theta}_{\gamma,t} \rangle$.

Example: Aircraft Black Box Item

Suppose that in the previous example failures occurred after 50, 90, 120, and 150 hours total test time. MIL-STD 781 does not require rejection after 1, 2, or 3 failures, nor acceptance before 150 hours. However, rejection occurs after the fourth failure (i.e., 150 hours) since it occurs before $t_{R4} \times \theta_1 = 3.46 \times 50 = 173$ hours, the lot is rejected, where the value $t_{R4} = 3.46$ is given in MIL-STD 781C.

An 80% lower confidence limit on the MTBF is calculated as follows: First find $\theta_{\gamma,t} = \theta_{.2,3}$ where $t = 150/\theta_1 = 3$. In Table II [t1] = 2.80 with $\underset{\sim}{\theta}_{.2,2.80} = 0.5646$ and [t2] = 3.46 with $\underset{\sim}{\theta}_{.2,3.46} = 0.6644$. Using Equation 1 we calculate $\underset{\sim}{\theta}_{.2,3} = .595$. An 80% lower confidence limit on the MTBF given a rejection after $3 \times \theta_1 = 150$ hours is $\underset{\sim}{\theta}_{.2,3} \times \theta_1 = .595 \times 50 = 29.7$ hours.

Similarly, we can calculate an 80% upper confidence limit. From Table II we obtain $\tilde{\theta}_{.2,2.8} = 1.5517$ and $\tilde{\theta}_{.2,3.46} = 1.7379$. giving $\tilde{\theta}_{.2,3} = 1.608$. An 80% upper confidence limit on the MTBF given a rejection after 150 hours is $\tilde{\theta}_{.2,3} \times \theta_1 = 1.608 \times 50 = 80.4$ hours.

A 60% confidence interval on the MTBF given a rejection after 150 hours is 29.7 to 80.4 hours.

3. CONCLUDING REMARKS

The well-known advantage of sequential life tests is considerably shorter average termination times than fixed-length tests at no increase in the error probabilities. This paper presents results which so far were only available for fixed-length tests, based on the work of Epstein [5]. They allow the calculation of confidence limits after a sequential test is terminated.

The methodology described in the Appendix can be applied to a variety of tests for the MTBF assuming an exponential distribution. It is not restricted to the tests listed in the standard.

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While our work was nearing completion, Dr. B.J. McDonald drew our attention to the similar, but not always identical, results of P. Luetjen, published in NAVSEC Report 6112-75-1. We also thank Professor L. A. Aroian, Dr. G. J. Hahn, and Dr. H. L. Harter for their suggestions and criticism.

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REFERENCES

[1] Aroian, L.A. (1963) "Exact Truncated Sequential Tests for the Exponential Density Function," Ninth National Symposium on Reliability and Quality Control, pp. 470-486.

[2] Aroian, L.A. (1968) "Sequential Analysis, direct method," Technometrics, 10, pp. 125-132.

[3] Aroian, L.A. (1976) "Application of the Direct Method in Sequential Analysis," Technometrics, 18, pp. 301-306.

[4] Aroian, L.A. and Oksoy, D. (1972) "Estimation, confidence intervals, and incentive plans for sequential three-way decision procedures," 1972 NATO Conference Proceedings on Reliability Testing and Evaluation, pp. VI-D-1 to VI-D-13.

[5] Epstein, B. (1960) "Estimation from Life Test Data," Technometrics, 2, pp. 447-454.

[6] Epstein, B., Patterson, A.A., and Qualls, C.R. (1963) "The Exact Analysis of Sequential Life Tests with Particular Application to AGREE Plans," Joint AIAA-SEA-ASME Aerospace Reliability and Maintainability Conference, May 1963.

[7] Epstein, B., and Sobel, M. (1955) "Sequential Life Tests in the Exponential Case," Annals of Mathematical Statistics, 26, pp. 82-93.

[8] Harter, H.L. (1964) "New Tables of the Incomplete Gamma Function Ratio and of Percentage Points of the Chi-Square and Beta Distribution," U.S. Government Printing Office, Washington, D.C.

[9] Harter, H.L. and Moore, A.H. (1976) "An Evaluation of Exponential and Weibull Test Plans," IEEE Transactions on Reliability, R-25, 100-104.

[10] Mann, N.R., Schafer, R.E. and Singpurwalla, N.D. (1974), Methods for Statistical Analysis of Reliability and Life Data, John Wiley & Sons, New York.

[11] MIL-STD 781C, Military Standard Reliability Qualification on Production Acceptance Tests: Exponential Distribution, Draft, 30 August 1976.

[12] Mood, A.M., Graybill, F.A. and Boes, D.C. (1974), Introduction to the Theory of Statistics (3rd ed.), McGraw-Hill, New York.

[13] Neathammer, R.D., Pabst, W.R. and Wigginton, C.G. (1965) "MIL-STD 781B, Reliability Tests: Exponential Distribution," Journal of Quality Technology, 1, pp. 58-67.

[14] Sumerlin, W.T. (1972), "Confidence Calculations for MIL-STD 781," 1972 Annual Reliability and Maintainability Symposium, IEEE Catalog Number 72CH0577-7B, pp. 205-212.

[15] Wald, A. (1947), Sequential Analysis, John Wiley & Sons, New York.

APPENDIX I

NOTATION

$1/\theta \exp\{-t/\theta\}$	=	Exponential failure density for $t > 0$, assumed for MIL-STD 781.
θ	=	Mean time between failures (MTBF).
θ_0	=	Design MTBF, such that if θ_0 is the true MTBF, the lot is accepted with a high probability $1-\alpha$.
θ_1	=	Low limit MTBF, such that if θ_1 is the true MTBF, the test is rejected with a high probability $1-\beta$.
t_{Ai}	=	The standard acceptance times so that a lot is accepted, if not more than i failures occur in a total test time $t_{Ai}\theta_1$ and the test has not been accepted or rejected before it. Also $t_{A0} \le t_{A1} \le \ldots \le t_{Ak}$.
t_{Ri}	=	The standard rejection times so that a lot is rejected, if $i > r$ or more failures occur on or before a total test time $t_{Ri}\theta_1$ and the test has not been accepted before it. Also $t_{Rr} \le t_{Rr+1} \le \ldots \le t_{Rr+1}$.

(i,t) = A point in the continuation region that can be reached only by the occurrence of exactly i failures in total accumulated test time t, without previously accepting or rejecting the test. Also, (i,t_{Ai}) is a point on the acceptance boundary and (i,t_{Ri}) is a point on the rejection boundary.

$P\{(i,t);\theta\}$ = The probability of i failures in total test time t, without an accept or reject decision before time t, based on a MTBF = θ.

a = Maximum number of failures allowed for acceptance.

r = Minimum number of failures required for rejection.

$t_{(i)}$ = The i-th largest standard termination time obtained by ordering a union of standard acceptance and rejection times such that $t_{(i-1)} \leq t_{(i)} \leq t_{(i+1)}$.

Δt_{ℓ} = Lengths of mutually exclusive intervals $(t_{\ell-1}, t_{\ell})$ of time defined by

$$\Delta t_1 = t_{(1)}$$

$$\Delta t_{\ell} = \begin{cases} t_{(\ell)} - t_{(\ell-1)} & \text{if } t_{(\ell)} > t_{(\ell-1)};\ \ell > 1 \\ t_{(\ell)} - t_{(s)} & \text{at vertical truncation} \end{cases}$$

where $t_{(s)}$ is the largest standardized termination time such that $t_{(s)} < t_{(\ell)}$. Clearly $\sum_{\ell=1}^{k} \Delta t_{\ell} = t_k$.

APPENDIX II

CALCULATION OF ACCEPTANCE AND CONTINUATION PROBABILITIES

In this Appendix we derive an expression for $P\{(i,t);\theta\}$, the probability that i failures have occurred in a total test time t without terminating the test. In particular, we show that

$$P\{(i,t);\theta\} = c(i,t)\exp\{-t/\theta\}(t/\theta)^{i}/i!$$

such that $c(i,t)$ is a constant which does not depend on the parameter θ but only on the test plan.

We use the direct method of Aroian [1,2] and an observation by Sumerlin [14] to calculate the constants $c(i,t)$ which greatly facilitate the calculation of confidence limits.

The regions of a sequential test plan for the exponential distribution are specified in the (failure, time) plane. The test is at a point (i,t) in the continuation region, if exactly i failures have occurred in a total test time t and the test has not been terminated prior to time t. We restrict our discussion without loss of generality to points with $t_{(i)}$, the ordered termination times as the second coordinate.

Consider a point $(i,t_{(k)})$. The time interval $\langle 0,t_{(k)}\rangle$ can be separated in mutually exclusive subintervals $\langle 0,t_{(1)}\rangle$, $\langle t_{(1)},t_{(2)}\rangle,\ldots,\langle t_{(k-1)},t_{(k)}\rangle$.

For a fixed MTBF = θ, the probability that δ_ℓ failures occur in one of these intervals $\langle t_{(\ell-1)}, t_{(\ell)} \rangle$ is by the assumption of exponentiality

$$P\{\delta_\ell \text{ failures in } \langle t_{(\ell-1)}, t_{(\ell)} \rangle ; \theta\} = \exp\{-\Delta t_\ell/\theta\} (\Delta t_\ell/\theta)^{\delta_\ell} / \delta_\ell!,$$

where δ_ℓ is a nonnegative integer random variable.

By the independence of the failure times, the probability of one possible test outcome $(\delta_1, \delta_2, \ldots, \delta_k)$ with i failures in a total test time $t_{(k)}$ is the product of the probabilities that δ_ℓ failures occur in each of the k subintervals $\langle t_{(\ell-1)}, t_{(\ell)} \rangle$, with the restriction that $\sum_{\ell=1}^{k} \delta_\ell = i$ and the test is not terminated before $t_{(k)}$. Formally we can write

$$P\{(\delta_1, \delta_2, \ldots \delta_k); \sum_{\ell=1}^{k} \delta_\ell = i, \text{ no termination before } t_{(k)}, \theta\}$$

$$= \sum_{\ell=1}^{k} \exp\{-\Delta t_\ell/\theta\} (\Delta t_\ell/\theta)^{\delta_\ell} / \delta_\ell!$$

$$= \prod_{\ell=1}^{k} \exp\{-\Delta t_\ell/\theta\} (1/\theta)^{\delta_\ell} \prod_{\ell=1}^{k} (\Delta t_\ell)^{\delta_\ell} / \delta_\ell!$$

$$= \exp\{-t_{(k)}/\theta\} (1/\theta)^{i} \prod_{\ell=1}^{k} (\Delta t_\ell)^{\delta_\ell} / \delta_\ell!$$

The probability of i failures in a total test time $t_{(k)}$ without termination prior to time t is

$$P\{(i,t_{(k)};\theta\} = \sum_{S} P\{(\delta_1,\delta_2,\ldots,\delta_k); \textstyle\sum\delta_\ell = i, \text{ no termination before } t_{(k)},\theta\}$$

$$= \exp\{-t_{(k)}/\theta\}\,(1/\theta)^i \sum_{S} \prod_{\ell=1}^{k} (\Delta t_\ell)^{\delta_\ell}/\delta_\ell!$$

$$= \exp\{-t_{(k)}/\theta\}\,(1/\theta)^i\, c'(i,t_{(k)}) \qquad \text{(AII-1)}$$

where $\sum_S$ denotes summation over all possible outcomes $(\delta_1,\delta_2,\ldots,\delta_k)$ which do not result in termination of the test before $t_{(k)}$ and $\sum\delta_\ell = i$. Note that the coefficient $c'(i,t_{(k)})$ does not depend on θ.

To calculate $c'(i,t_{(k)})$ by direct enumeration over all possible outcomes $(\delta_1,\delta_2,\ldots,\delta_k)$ is still very cumbersome. Instead we use the direct method of Aroian [2] to evaluate $P\{(i,t_{(k)});\theta\}$ for some value of θ, say $\theta = 1$. Then we divide by the Poisson probability of i failures in time $t_{(k)}$ given θ. This yields

$$c(i,t_{(k)}) = c'(i,t_{(k)})\exp\{-t_{(k)}/\theta\}(1/\theta)^i \Big/ \left(\exp\{-t_{(k)}/\theta\}t_{(k)}^i(1/\theta)^i/i!\right)$$

$$= c'(i,t_{(k)})\,i!\,(1/t_{(k)})^i \qquad \text{(AII-2)}$$

For tabulation the coefficients $c(i,t_{(k)})$ are preferable to $c'(i,t_{(k)})$ since they have a more convenient range for combinations of i and $t_{(k)}$. Thus we have shown that the probability that i failures have occured in a total test time $t_{(k)}$ without prior termination is

$$P\{(i,t_{(k)});\theta\} = c(i,t)\exp\{-t_{(k)}/\theta\}(t_{(k)}/\theta)^i/i!$$

APPENDIX III

DERIVATION OF CONFIDENCE LIMITS

In this Appendix we derive separate $(1-\gamma)100\%$ upper and lower confidence limits on the MTBF, for sequential tests of MIL-STD 781. Different derivations are necessary since the time to termination by acceptance is a discrete, "Pascal-type" random variable, whereas the time to termination by rejection is a continuous "gamma-like" random variable. The observations after acceptance are time-censored; after rejection they are failure-censored.

Confidence Limits at Acceptance

In this section we derive conservative standardized $(1-\gamma)100\%$ lower and upper confidence limits on the MTBF for the case that an accept decision has been reached based on i failures occurring in a total standardized test time t_{Ai}, $i=1,\ldots,a$. Accept decisions can be made only at the discrete set of test times $\{t_{Ai}; i=1,\ldots a\}$. Thus the time to acceptance is a "Pascal-type" random variable. The probability to accept with exactly i failures is discrete.

Confidence limits are derived using the statistical method described in Mood, Graybill and Boes [12]. For discrete distributions this method gives conservative confidence limits. Let P $\{(s,t_{As});\theta\}$ be defined as before. Suppose the test is accepted after t_{Ai} time units with i failures.

A conservative standardized $(1-\gamma)100\%$ lower confidence limit $\underset{\sim}{\theta}_{\gamma,i}$ on the MTBF satisfies the equation

$$\gamma = \sum_{s=0}^{i} P\{(s,t_{As});\underset{\sim}{\theta}_{\gamma,i}\}$$

$$= \sum_{s=0}^{i} c(s,t_{As})\exp\{-t_{As}/\underset{\sim}{\theta}_{\gamma,i}\}(t_{As}/\underset{\sim}{\theta}_{\gamma,i})^{s} \qquad \text{(AIII-1)}$$

Similarly, a conservative standardized $(1-\gamma)100\%$ upper confidence limit $\tilde{\theta}_{\gamma,i}$ on the MTBF satisfies the equation

$$\gamma = \sum_{s=i}^{a} P\{(s,t_{As});\tilde{\theta}_{\gamma,i}\} + P\{\text{rejection of test};\tilde{\theta}_{\gamma,i}\}$$

This is equivalent to writing

$$1-\gamma = \sum_{s=0}^{i-1} P\{(s,t_{As});\tilde{\theta}_{\gamma,i}\}$$

$$= \sum_{s=0}^{i-1} c(s,t_{As})\exp\{-t_{As}/\tilde{\theta}_{\gamma,i}\}(t_{As}/\tilde{\theta}_{\gamma,i})^{s} \qquad \text{(AIII-2)}$$

A conservative standardized $(1-\gamma)100\%$ two-sided confidence interval on the true MTBF is $(\underset{\sim}{\theta}_{\gamma/2,i},\tilde{\theta}_{\gamma/2,i})$.

Equations AIII-1 and AIII-2 can be solved for $\underset{\sim}{\theta}_{\gamma,i}$ and $\tilde{\theta}_{\gamma,i}$ by the bisection method. The coefficients $c(s,t)$ are calculated as described in Appendix II.

Confidence Limits at Rejection

In this section we derive exact $(1-\gamma)100\%$ lower and upper confidence limits on the MTBF, for the case that a reject decision has been reached based on i failures occurring after a total test time t, where $t_{Ri-1} \le t \le t_{Ri}$ and $r \le i \le a+1$.

Reject decisions can be reached at any time as soon as a certain minimum number of failures have occurred (this minimum number depends on t). Thus the time to rejection is a continuous "gamma-like" random variable.

Confidence limits can be derived as follows: let $P_{Rej}(t;\theta)$ be the probability that a test results in a reject decision on or before a total test time t, given that the MTBF is θ. The test is terminated with a reject decision at time t with i failures, where $t_{Ri-1} \le t \le t_{Ri}$ and $r \le i \le a+1$.

A standardized $(1-\gamma)100\%$ lower confidence limit $\underset{\sim}{\theta}_{\gamma,t}$ satisfies the equation

$$\gamma = P_{Rej}(t;\underset{\sim}{\theta}_{\gamma,t}). \qquad \text{(AIII-3)}$$

A standardized $(1-\gamma)100\%$ upper confidence limit $\tilde{\theta}_{\gamma,t}$ satisfies the equation

$$1-\gamma = P_{Rej}(t;\tilde{\theta}_{\gamma,t}). \qquad \text{(AIII-4)}$$

Noting that

$$P_{Rej}(t;\theta) = 1 - P(\text{Acceptance on or before } t;\theta) - P(\text{Continuation at } t;\theta) \qquad \text{(AIII-5)}$$

it is possible to express $P_{Rej}(t;\theta)$ in terms of the equations (AII-1) and (AII-2) In particular, for $t_{Ri-1} < t < t_{Ri}$ and $r < i < a+1$,

$$P(\text{Acceptance on or before } t;\theta) = \sum_{s=0}^{n(t)} P\{(s,t_{As});\theta\} \qquad \text{(AIII-6)}$$

and

$$P(\text{Continuation at } t;\theta) = \sum_{s=n(t)+1}^{i-1} P\{(s,t);\theta\} \qquad \text{(AIII-7)}$$

where $n(t)$ is the maximum number of failures which may occur such that an accept decision occurs on or before a total test time t. We combine equations (AIII-5), (AIII-6), and (AIII-7) and substitute them into (AIII-3) and (AIII-4). These latter equations are solved for $\underset{\sim}{\theta}_{\gamma,t}$ and $\tilde{\theta}_{\gamma,t}$ for various values of γ by the bisection method. We tabulate confidence limits at selected values t such that the linear interpolation between the t's is convenient.

LOWER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN I D = 1.5 ALPHA = BETA = 0.10

NUMBER OF FAILURES i	TOTAL TEST TIME	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
0	6.60	9.5218	5.4818	4.1008	2.8664	2.2031
1	7.82	4.5976	3.1618	2.5747	1.9807	1.6230
2	9.03	3.3006	2.4386	2.0589	1.6531	1.3957
3	10.25	2.7074	2.0843	1.7977	1.4811	1.2737
4	11.46	2.3664	1.8726	1.6387	1.3743	1.1971
5	12.68	2.1462	1.7326	1.5324	1.3022	1.1453
6	13.91	1.9928	1.6337	1.4569	1.2508	1.1083
7	15.12	1.8735	1.5591	1.3996	1.2117	1.0802
8	16.34	1.7908	1.5014	1.3553	1.1814	1.0585
9	17.55	1.7210	1.4552	1.3197	1.1571	1.0412
10	18.77	1.6645	1.4177	1.2908	1.1374	1.0273
11	19.98	1.6175	1.3864	1.2667	1.1210	1.0158
12	21.20	1.5781	1.3602	1.2465	1.1074	1.0063
13	22.41	1.5443	1.3376	1.2292	1.0957	.9982
14	23.63	1.5153	1.3183	1.2143	1.0858	.9913
15	24.84	1.4899	1.3014	1.2013	1.0772	.9854
16	26.06	1.4677	1.2866	1.1900	1.0697	.9804
17	27.29	1.4482	1.2736	1.1802	1.0632	.9760
18	28.50	1.4307	1.2620	1.1713	1.0574	.9722
19	29.72	1.4150	1.2516	1.1635	1.0523	.9688
20	30.93	1.4009	1.2423	1.1564	1.0477	.9658
21	32.15	1.3881	1.2338	1.1500	1.0437	.9632
22	33.36	1.3764	1.2262	1.1442	1.0400	.9608
23	34.58	1.3658	1.2192	1.1390	1.0367	.9588
24	35.79	1.3561	1.2128	1.1342	1.0337	.9569
25	37.01	1.3472	1.2070	1.1299	1.0310	.9552
26	38.22	1.3390	1.2016	1.1259	1.0285	.9537
27	39.44	1.3314	1.1967	1.1223	1.0263	.9523
28	40.67	1.3245	1.1922	1.1190	1.0243	.9511
29	41.88	1.3180	1.1881	1.1159	1.0224	.9500
30	43.10	1.3120	1.1842	1.1131	1.0207	.9490
31	44.31	1.3054	1.1806	1.1104	1.0192	.9481
32	45.53	1.3012	1.1773	1.1080	1.0177	.9472
33	46.74	1.2964	1.1741	1.1057	1.0164	.9465
34	47.96	1.2918	1.1713	1.1036	1.0152	.9458
35	49.17	1.2876	1.1685	1.1017	1.0141	.9452
36	49.50	1.2797	1.1632	1.0977	1.0116	.9437
37	49.50	1.2652	1.1533	1.0899	1.0064	.9404
38	49.50	1.2493	1.1403	1.0791	.9987	.9351
39	49.50	1.2308	1.1254	1.0664	.9890	.9279
40	49.50	1.2120	1.1097	1.0526	.9780	.9194

Table I: $(1-\gamma)100\%$ standardized confidence limits on MTBF after accept decision. (LOWER - $\underset{\sim}{\theta}_{\gamma,i}$)

LOWER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN II D = 1.5 ALPHA = BETA = 0.20

NUMBER OF FAILURES i	TOTAL TEST TIME	γ= .50	γ= .30	γ= .20	γ= .10	γ= .05
0	4.19	6.0449	3.4801	2.6034	1.8197	1.3987
1	5.40	3.1261	2.1477	1.7475	1.3425	1.0984
2	6.62	2.3601	1.7401	1.4669	1.1746	.9889
3	7.83	2.0077	1.5412	1.3264	1.0887	.9326
4	9.05	1.8059	1.4246	1.2432	1.0376	.8993
5	10.26	1.6768	1.3478	1.1882	1.0039	.8776
6	11.49	1.5873	1.2946	1.1501	.9808	.8631
7	12.71	1.5218	1.2555	1.1222	.9641	.8527
8	13.92	1.4718	1.2256	1.1009	.9515	.8451
9	15.14	1.4330	1.2024	1.0844	.9419	.8394
10	16.35	1.4019	1.1839	1.0714	.9344	.8351
11	17.57	1.3759	1.1691	1.0610	.9286	.8317
12	18.78	1.3563	1.1568	1.0525	.9239	.8292
13	19.99	1.3392	1.1467	1.0455	.9201	.8271
14	21.21	1.3249	1.1384	1.0398	.9170	.8255
15	21.90	1.3072	1.1273	1.0320	.9127	.8232
16	21.90	1.2764	1.1059	1.0155	.9023	.8169
17	21.90	1.2420	1.0799	.9943	.8874	.8068
18	21.90	1.2109	1.0546	.9727	.8709	.7946

LOWER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN III D = 2.0 ALPHA = BETA = 0.10

NUMBER OF FAILURES i	TOTAL TEST TIME	γ= .50	γ= .30	γ= .20	γ= .10	γ= .05
0	4.40	6.3479	3.6546	2.7339	1.9109	1.4688
1	5.79	3.3364	2.2913	1.8638	1.4311	1.1704
2	7.18	2.5435	1.8741	1.5790	1.2633	1.0627
3	8.56	2.1789	1.6712	1.4372	1.1783	1.0080
4	9.94	1.9708	1.5521	1.3532	1.1278	.9760
5	11.34	1.8385	1.4754	1.2992	1.0956	.9559
6	12.72	1.7466	1.4218	1.2614	1.0734	.9424
7	14.10	1.6799	1.3827	1.2339	1.0575	.9329
8	15.49	1.6300	1.3535	1.2135	1.0459	.9262
9	16.88	1.5916	1.3311	1.1980	1.0372	.9213
10	18.26	1.5613	1.3135	1.1858	1.0305	.9177
11	19.65	1.5371	1.2995	1.1763	1.0254	.9150
12	20.60	1.5112	1.2839	1.1654	1.0194	.9117
13	20.60	1.4661	1.2530	1.1418	1.0045	.9026
14	20.60	1.4173	1.2163	1.1120	.9835	.8882
15	20.60	1.3755	1.1825	1.0830	.9613	.8715

Table I: (cont'd) (LOWER - $\underset{\sim}{\theta}_{\gamma,i}$)

LOWER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN IV D = 2.0 ALPHA = BETA = 0.20

NUMBER OF FAILURES i	TOTAL TEST TIME	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
0	2.80	4.0395	2.3256	1.7397	1.2160	.9347
1	4.18	2.3277	1.5933	1.2927	.9880	.8042
2	5.58	1.8907	1.3822	1.1581	.9181	.7650
3	6.96	1.6935	1.2865	1.0968	.8869	.7485
4	8.34	1.5977	1.2351	1.0643	.8710	.7407
5	9.74	1.5385	1.2054	1.0459	.8626	.7368
6	9.74	1.4486	1.1502	1.0066	.8403	.7245
7	9.74	1.3753	1.0986	.9662	.8133	.7069

LOWER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN V D = 3.0 ALPHA = BETA = 0.10

NUMBER OF FAILURES i	TOTAL TEST TIME	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
0	3.75	5.4101	3.1147	2.3300	1.6286	1.2518
1	5.40	3.0397	2.0831	1.6915	1.2950	1.0557
2	7.05	2.4208	1.7755	1.4909	1.1861	.9918
3	8.70	2.1462	1.6333	1.3972	1.1357	.9633
4	10.35	1.9966	1.5547	1.3457	1.1087	.9487
5	10.35	1.7947	1.4266	1.2504	1.0481	.9093
6	10.35	1.6326	1.3112	1.1575	.9811	.8600

LOWER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN VI D = 3.0 ALPHA = BETA = 0.20

NUMBER OF FAILURES i	TOTAL TEST TIME	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
0	2.67	3.8520	2.2177	1.6590	1.1596	.8913
1	4.32	2.3418	1.5980	1.2932	.9842	.7974
2	4.50	1.6344	1.2039	1.0142	.8111	.6818

Table I: (cont'd) (LOWER - $\underset{\sim}{\theta}_{\gamma,i}$)

LOWER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN VII D = 1.5 ALPHA = BETA = 0.30

NUMBER OF FAILURES i	TOTAL TEST TIME	Y=.50	Y=.30	Y=.20	Y=.10	Y=.05
0	3.15	4.5445	2.6163	1.9572	1.3680	1.0515
1	4.37	2.4854	1.7049	1.3856	1.0622	.8673
2	5.58	1.9410	1.4273	1.2007	.9580	.8035
3	6.80	1.6951	1.2959	1.1118	.9077	.7733
4	6.80	1.4214	1.1207	.9784	.8175	.7092
5	6.80	1.2142	.9756	.8611	.7302	.6412

LOWER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN VIII D = 2.0 ALPHA = BETA = 0.30

NUMBER OF FAILURES i	TOTAL TEST TIME	Y=.50	Y=.30	Y=.20	Y=.10	Y=.05
0	1.72	2.4814	1.4286	1.0687	.7470	.5742
1	3.10	1.6120	1.0939	.8814	.6656	.5352
2	4.50	1.3867	1.0011	.8298	.6451	.5258

Table I: (cont'd) (LOWER - $\underset{\sim}{\theta}_{\gamma,i}$)

UPPER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN I D = 1.5 ALPHA = BETA = 0.10

NUMBER OF FAILURES i	TOTAL TEST TIME	$\gamma = .50$	$\gamma = .30$	$\gamma = .20$	$\gamma = .10$	$\gamma = .05$
0	6.60	(1)	(1)	(1)	(1)	(1)
1	7.82	9.5218	18.5043	29.5773	62.6420	128.6742
2	9.03	4.5976	7.0344	9.3651	14.5198	21.7317
3	10.25	3.3006	4.6155	5.7565	8.0215	10.8141
4	11.46	2.7074	3.6017	4.3365	5.7125	7.2981
5	12.68	2.3664	3.0469	3.5864	4.5592	5.6329
6	13.91	2.1462	2.6995	3.1268	3.8772	4.6806
7	15.12	1.9928	2.4623	2.8179	3.4297	4.0699
8	16.34	1.8785	2.2886	2.5942	3.1118	3.6437
9	17.55	1.7908	2.1567	2.4260	2.8759	3.3316
10	18.77	1.7210	2.0527	2.2941	2.6931	3.0924
11	19.98	1.6645	1.9690	2.1886	2.5482	2.9043
12	21.20	1.6175	1.8998	2.1017	2.4297	2.7517
13	22.41	1.5781	1.8420	2.0294	2.3317	2.6262
14	23.63	1.5443	1.7927	1.9679	2.2488	2.5205
15	24.84	1.5153	1.7504	1.9153	2.1782	2.4308
16	26.06	1.4899	1.7135	1.8695	2.1169	2.3534
17	27.29	1.4677	1.6812	1.8295	2.0635	2.2862
18	28.50	1.4482	1.6529	1.7944	2.0169	2.2276
19	29.72	1.4307	1.6275	1.7630	1.9752	2.1754
20	30.93	1.4150	1.6048	1.7349	1.9381	2.1290
21	32.15	1.4009	1.5843	1.7096	1.9046	2.0873
22	33.36	1.3881	1.5657	1.6868	1.8745	2.0499
23	34.58	1.3764	1.5488	1.6659	1.8472	2.0159
24	35.79	1.3658	1.5335	1.6470	1.8224	1.9852
25	37.01	1.3561	1.5194	1.6297	1.7996	1.9571
26	38.22	1.3472	1.5065	1.6138	1.7788	1.9315
27	39.44	1.3390	1.4945	1.5991	1.7597	1.9079
28	40.67	1.3314	1.4836	1.5857	1.7421	1.8863
29	41.88	1.3245	1.4735	1.5733	1.7260	1.8666
30	43.10	1.3180	1.4641	1.5618	1.7110	1.8482
31	44.31	1.3120	1.4554	1.5511	1.6971	1.8312
32	45.53	1.3064	1.4472	1.5411	1.6841	1.8154
33	46.74	1.3012	1.4397	1.5318	1.6721	1.8008
34	47.96	1.2964	1.4325	1.5231	1.6608	1.7872
35	49.17	1.2918	1.4259	1.5150	1.6503	1.7745
36	49.50	1.2876	1.4197	1.5073	1.6405	1.7627
37	49.50	1.2797	1.4088	1.4944	1.6246	1.7442
38	49.50	1.2662	1.3913	1.4744	1.6010	1.7177
39	49.50	1.2493	1.3705	1.4512	1.5746	1.6889
40	49.50	1.2308	1.3485	1.4272	1.5479	1.6606

(1) THE UPPER LIMIT ON THETA IS INFINITE, WITH ZERO OBSERVED FAILURES

Table I: (cont'd) (UPPER - $\tilde{\theta}_{\gamma,i}$)

UPPER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN II D = 1.5 ALPHA = BETA = 0.20

NUMBER OF FAILURES i	TOTAL TEST TIME	γ = .50	γ = .30	γ = .20	γ = .10	γ = .05
0	4.19	(1)	(1)	(1)	(1)	(1)
1	5.40	6.0449	11.7474	18.7771	39.7682	81.6886
2	6.62	3.1261	4.7865	6.3746	9.8867	14.8006
3	7.83	2.3601	3.3054	4.1254	5.7531	7.7597
4	9.05	2.0077	2.6766	3.2260	4.2544	5.4393
5	10.26	1.8069	2.3329	2.7497	3.5009	4.3300
6	11.49	1.6768	2.1162	2.4553	3.0507	3.6884
7	12.71	1.5873	1.9693	2.2585	2.7563	3.2780
8	13.92	1.5218	1.8630	2.1175	2.5491	2.9943
9	15.14	1.4718	1.7827	2.0117	2.3961	2.7881
10	16.35	1.4330	1.7207	1.9307	2.2801	2.6339
11	17.57	1.4019	1.6713	1.8666	2.1895	2.5150
12	18.78	1.3769	1.6317	1.8153	2.1179	2.4221
13	19.99	1.3563	1.5992	1.7735	2.0599	2.3480
14	21.21	1.3392	1.5722	1.7389	2.0127	2.2884
15	21.90	1.3249	1.5498	1.7103	1.9739	2.2403
16	21.90	1.3072	1.5233	1.6776	1.9316	2.1901
17	21.90	1.2764	1.4819	1.6293	1.8743	2.1273
18	21.90	1.2420	1.4391	1.5818	1.8219	2.0744

UPPER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN III D = 2.0 ALPHA = BETA = 0.10

NUMBER OF FAILURES i	TOTAL TEST TIME	γ = .50	γ = .30	γ = .20	γ = .10	γ = .05
0	4.40	(1)	(1)	(1)	(1)	(1)
1	5.79	6.3479	12.3362	19.7182	41.7613	85.7828
2	7.18	3.3364	5.1098	6.8060	10.5571	15.8052
3	8.56	2.5435	3.5638	4.4489	6.2057	8.3716
4	9.94	2.1789	2.9069	3.5047	4.6238	5.9135
5	11.34	1.9708	2.5470	3.0036	3.8270	4.7365
6	12.72	1.8385	2.3236	2.6983	3.3570	4.0641
7	14.10	1.7466	2.1710	2.4928	3.0484	3.6333
8	15.49	1.6799	2.0615	2.3469	2.8333	3.3390
9	16.88	1.6300	1.9802	2.2395	2.6775	3.1295
10	18.26	1.5916	1.9181	2.1579	2.5608	2.9752
11	19.65	1.5613	1.8692	2.0941	2.4709	2.8585
12	20.60	1.5371	1.8303	2.0438	2.4009	2.7693
13	20.60	1.5112	1.7905	1.9936	2.3339	2.6873
14	20.60	1.4661	1.7287	1.9206	2.2453	2.5880
15	20.60	1.4173	1.6671	1.8515	2.1682	2.5092

(1) THE UPPER LIMIT ON THETA IS INFINITE, WITH ZERO OBSERVED FAILURES

Table I: (cont'd) (UPPER - $\tilde{\theta}_{\gamma,i}$)

UPPER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN IV D = 2.0 ALPHA = BETA = 0.20

NUMBER OF FAILURES i	TOTAL TEST TIME	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
0	2.80	(1)	(1)	(1)	(1)	(1)
1	4.18	4.0395	7.8503	12.5480	26.5754	54.5891
2	5.58	2.3277	3.5732	4.7640	7.3975	11.0817
3	6.96	1.8907	2.6681	3.3453	4.6985	6.3838
4	8.34	1.6995	2.2978	2.7963	3.7496	4.8858
5	9.74	1.5977	2.1073	2.5225	3.3033	4.2253
6	9.74	1.5385	1.9983	2.3693	3.0652	3.8936
7	9.74	1.4486	1.8613	2.1971	2.8387	3.6262

UPPER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN V D = 3.0 ALPHA = BETA = 0.10

NUMBER OF FAILURES i	TOTAL TEST TIME	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
0	3.75	(1)	(1)	(1)	(1)	(1)
1	5.40	5.4101	10.5138	16.8053	35.5920	73.1104
2	7.05	3.0397	4.6625	6.2143	9.6459	14.4469
3	8.70	2.4208	3.4052	4.2604	5.9625	8.0694
4	10.35	2.1462	2.8849	3.4956	4.6508	6.0038
5	10.35	1.9966	2.6113	3.1057	4.0178	5.0622
6	10.35	1.7947	2.3001	2.7039	3.4489	4.3109

UPPER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN VI D = 3.0 ALPHA = BETA = 0.20

NUMBER OF FAILURES i	TOTAL TEST TIME	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
0	2.67	(1)	(1)	(1)	(1)	(1)
1	4.32	3.8520	7.4858	11.9654	25.3415	52.0546
2	4.50	2.3418	3.6027	4.8080	7.4730	11.2010

(1) THE UPPER LIMIT ON THETA IS INFINITE, WITH ZERO OBSERVED FAILURES

Table I: (cont'd) (UPPER - $\tilde{\theta}_{\gamma,i}$)

UPPER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN VII D = 1.5 ALPHA = BETA = 0.30

NUMBER OF FAILURES i	TOTAL TEST TIME	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
0	3.15	(1)	(1)	(1)	(1)	(1)
1	4.37	4.5445	8.8316	14.1165	29.8973	61.4127
2	5.58	2.4854	3.8096	5.0760	7.8765	11.7945
3	6.80	1.9410	2.7236	3.4022	4.7491	6.4095
4	6.80	1.6951	2.2673	2.7375	3.6186	4.6358
5	6.80	1.4214	1.8373	2.1686	2.7706	3.4423

UPPER CONFIDENCE LIMITS FOR THETA ON THE ACCEPTANCE BOUNDARY

MIL-STD-781C TEST PLAN VIII D = 2.0 ALPHA = BETA = 0.30

NUMBER OF FAILURES i	TOTAL TEST TIME	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
0	1.72	(1)	(1)	(1)	(1)	(1)
1	3.10	2.4814	4.8273	7.7080	16.3249	33.5333
2	4.50	1.6120	2.4894	3.3277	5.1811	7.7733

(1) THE UPPER LIMIT ON THETA IS INFINITE, WITH ZERO OBSERVED FAILURES

Table I: (cont'd) (UPPER - $\tilde{\theta}_{\gamma,i}$)

LOWER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN I D = 1.5 ALPHA = BETA = 0.10

NUMBER OF FAILURES	TOTAL TEST TIME t	γ= .50	γ= .30	γ= .20	γ= .10	γ= .05
6	.68	.1199	.0971	.0860	.0733	.0647
7	1.89	.2835	.2331	.2083	.1795	.1596
8	3.11	.4072	.3389	.3049	.2649	.2371
9	4.32	.5031	.4228	.3824	.3346	.3010
10	5.54	.5815	.4926	.4476	.3939	.3559
11	6.75	.6454	.5505	.5021	.4441	.4028
12	7.97	.6997	.6004	.5495	.4881	.4443
13	9.18	.7453	.6430	.5902	.5264	.4806
14	10.40	.7852	.6806	.6265	.5606	.5132
15	11.61	.8194	.7134	.6582	.5909	.5422
16	12.83	.8499	.7428	.6868	.6184	.5687
17	14.06	.8773	.7695	.7129	.6436	.5932
18	15.27	.9012	.7929	.7360	.6660	.6150
19	16.49	.9228	.8143	.7572	.6867	.6352
20	17.70	.9420	.8336	.7763	.7055	.6537
21	18.92	.9596	.8513	.7940	.7230	.6709
22	20.13	.9754	.8674	.8101	.7390	.6867
23	21.35	.9901	.8824	.8251	.7540	.7016
24	22.56	1.0033	.8960	.8389	.7678	.7153
25	23.78	1.0157	.9088	.8518	.7808	.7282
26	24.99	1.0269	.9205	.8637	.7928	.7402
27	26.21	1.0374	.9315	.8749	.8041	.7516
28	27.44	1.0473	.9420	.8855	.8149	.7624
29	28.65	1.0562	.9515	.8952	.8248	.7723
30	29.85	1.0644	.9602	.9042	.8339	.7815
31	31.08	1.0723	.9686	.9129	.8428	.7905
32	32.30	1.0797	.9765	.9210	.8511	.7988
33	33.51	1.0864	.9838	.9285	.8588	.8066
34	34.73	1.0928	.9908	.9357	.8662	.8141
35	35.94	1.0987	.9972	.9423	.8731	.8210
36	37.16	1.1044	1.0034	.9487	.8796	.8276
37	38.37	1.1096	1.0091	.9546	.8858	.8338
38	39.59	1.1145	1.0145	.9603	.8916	.8397
39	40.82	1.1193	1.0198	.9658	.8973	.8454
40	42.03	1.1236	1.0246	.9708	.9025	.8506
41	43.10	1.1269	1.0283	.9746	.9064	.8546
41	44.31	1.1369	1.0388	.9853	.9170	.8649
41	45.53	1.1517	1.0536	.9998	.9308	.8779
41	46.74	1.1691	1.0703	1.0159	.9457	.8914
41	47.96	1.1880	1.0880	1.0325	.9607	.9047
41	49.17	1.2069	1.1051	1.0484	.9745	.9165
41	49.50	1.2120	1.1097	1.0526	.9780	.9194

Table II: $(1-\gamma)100\%$ standardized confidence limits on MTBF after reject decision (LOWER - $\underset{\sim}{\theta}_{\gamma,t}$)

LOWER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN II D = 1.5 ALPHA = BETA = 0.20

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
3	.24	.0898	.0664	.0561	.0451	.0381
4	1.46	.3981	.3069	.2649	.2187	.1884
5	2.67	.5831	.4605	.4028	.3380	.2947
6	3.90	.7133	.5733	.5063	.4299	.3782
7	5.12	.8075	.6577	.5851	.5015	.4444
8	6.33	.8783	.7231	.6472	.5590	.4983
9	7.55	.9347	.7765	.6985	.6073	.5440
10	8.76	.9794	.8198	.7406	.6474	.5824
11	9.98	1.0165	.8564	.7765	.6821	.6158
12	11.19	1.0468	.8869	.8067	.7114	.6442
13	12.41	1.0725	.9131	.8328	.7370	.6691
14	13.62	1.0938	.9352	.8549	.7588	.6903
15	14.84	1.1122	.9544	.8743	.7780	.7090
16	16.05	1.1277	.9708	.8909	.7944	.7249
17	17.28	1.1413	.9854	.9056	.8090	.7390
18	18.50	1.1530	.9980	.9184	.8216	.7511
19	18.78	1.1536	.9986	.9191	.8223	.7519
19	19.99	1.1675	1.0135	.9340	.8368	.7654
19	21.21	1.1937	1.0389	.9582	.8586	.7844
19	21.90	1.2109	1.0546	.9727	.8709	.7946

MIL-STD-781C TEST PLAN III D = 2.0 ALPHA = BETA = 0.10

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
3	.70	.2618	.1936	.1636	.1315	.1112
4	2.08	.5724	.4403	.3798	.3131	.2696
5	3.48	.7696	.6062	.5296	.4437	.3865
6	4.40	.8403	.6700	.5894	.4983	.4371
6	4.86	.9027	.7232	.6377	.5405	.4751
7	5.79	.9535	.7705	.6832	.5830	.5151
7	6.24	.9998	.8117	.7210	.6169	.5460
8	7.18	1.0383	.8488	.7570	.6512	.5788
8	7.63	1.0746	.8818	.7880	.6795	.6050
9	8.56	1.1037	.9107	.8164	.7069	.6315
9	9.02	1.1332	.9382	.8425	.7312	.6541
10	9.94	1.1556	.9610	.8652	.7534	.6758
10	10.40	1.1793	.9836	.8870	.7738	.6951
11	11.34	1.1980	1.0029	.9063	.7930	.7138
11	11.79	1.2170	1.0214	.9244	.8100	.7300
12	12.72	1.2319	1.0371	.9402	.8258	.7454
12	13.18	1.2479	1.0530	.9557	.8406	.7595
13	14.10	1.2599	1.0657	.9687	.8536	.7722
13	14.56	1.2731	1.0790	.9818	.8661	.7841
14	15.49	1.2831	1.0899	.9929	.8772	.7950
14	15.94	1.2939	1.1009	1.0038	.8877	.8049
15	16.88	1.3025	1.1102	1.0133	.8973	.8142
15	17.34	1.3118	1.1199	1.0229	.9064	.8227
16	18.26	1.3187	1.1275	1.0307	.9142	.8303
16	19.65	1.3484	1.1572	1.0595	.9409	.8543
16	20.60	1.3755	1.1825	1.0830	.9613	.8715

Table II: (cont'd) (LOWER - $\underset{\sim}{\theta}_{\gamma,t}$)

LOWER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN IV D = 2.0 ALPHA = BETA = 0.20

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
2	.70	.4171	.2870	.2338	.1800	.1476
3	2.08	.8127	.5944	.4997	.3996	.3367
4	2.80	.8914	.6643	.5646	.4578	.3898
4	3.46	1.0284	.7767	.6644	.5428	.4646
5	4.18	1.0734	.8193	.7052	.5809	.5004
5	4.86	1.1634	.8977	.7768	.6438	.5567
6	5.58	1.1910	.9251	.8036	.6693	.5809
6	6.24	1.2478	.9767	.8515	.7120	.6192
7	6.96	1.2654	.9948	.8694	.7291	.6353
7	7.62	1.3031	1.0301	.9026	.7586	.6612
8	8.34	1.3147	1.0423	.9146	.7700	.6717
8	9.74	1.3763	1.0986	.9662	.8133	.7069

LOWER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN V D = 3.0 ALPHA = BETA = 0.10

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
2	.57	.3396	.2337	.1904	.1465	.1202
3	2.22	.8514	.6256	.5271	.4225	.3564
4	3.75	1.0933	.8334	.7141	.5845	.5008
4	3.87	1.1275	.8559	.7338	.6010	.5152
5	5.40	1.2816	.9932	.8613	.7156	.6200
5	5.52	1.3007	1.0094	.8758	.7282	.6313
6	7.05	1.4030	1.1049	.9664	.8118	.7089
6	7.17	1.4164	1.1166	.9772	.8213	.7175
7	8.70	1.4866	1.1845	1.0427	.8825	.7746
7	10.35	1.6326	1.3112	1.1575	.9811	.8600

LOWER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN VI D = 3.0 ALPHA = BETA = 0.20

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
2	.36	.2145	.1476	.1202	.0926	.0759
3	2.67	1.0053	.7422	.6266	.5034	.4253
3	4.32	1.5801	1.1648	.9819	.7862	.6618
3	4.50	1.6344	1.2039	1.0142	.8111	.6818

Table II: (cont'd) (LOWER - $\underset{\sim}{\theta}_{\gamma,t}$)

LOWER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN VII D = 1.5 ALPHA = BETA = 0.30

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
3	1.22	.4562	.3374	.2851	.2292	.1938
4	2.43	.6856	.5245	.4513	.3710	.3188
5	3.15	.7501	.5824	.5052	.4199	.3638
5	3.65	.8322	.6511	.5671	.4735	.4115
6	4.37	.8743	.6908	.6050	.5089	.4448
6	5.58	1.0323	.8263	.7283	.6172	.5422
6	6.80	1.2142	.9756	.8611	.7302	.6412

LOWER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN VIII D = 2.0 ALPHA = BETA = 0.30

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
3	1.72	.6432	.4757	.4020	.3232	.2732
3	3.10	1.1121	.8183	.6885	.5494	.4605
3	4.50	1.3867	1.0011	.8298	.6451	.5268

Table II: (cont'd) (LOWER - $\underset{\sim}{\theta}_{\gamma,t}$)

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UPPER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C   TEST PLAN I   D = 1.5   ALPHA = BETA = 0.10

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
6	.68	.1199	.1505	.1742	.2157	.2602
7	1.89	.2835	.3494	.3995	.4855	.5757
8	3.11	.4072	.4951	.5609	.6724	.7873
9	4.32	.5031	.6052	.6807	.8074	.9365
10	5.54	.5815	.6933	.7751	.9114	1.0488
11	6.75	.6454	.7636	.8496	.9917	1.1339
12	7.97	.6997	.8224	.9111	1.0567	1.2015
13	9.18	.7453	.8711	.9614	1.1090	1.2550
14	10.40	.7852	.9129	1.0042	1.1528	1.2991
15	11.61	.8194	.9484	1.0402	1.1890	1.3350
16	12.83	.8499	.9796	1.0716	1.2201	1.3654
17	14.06	.8773	1.0073	1.0992	1.2472	1.3915
18	15.27	.9012	1.0311	1.1228	1.2700	1.4132
19	16.49	.9228	1.0525	1.1438	1.2900	1.4320
20	17.70	.9420	1.0713	1.1621	1.3073	1.4480
21	18.92	.9596	1.0884	1.1786	1.3227	1.4621
22	20.13	.9754	1.1036	1.1932	1.3361	1.4742
23	21.35	.9901	1.1176	1.2065	1.3482	1.4850
24	22.56	1.0033	1.1301	1.2184	1.3589	1.4944
25	23.78	1.0157	1.1416	1.2293	1.3686	1.5029
26	24.99	1.0269	1.1521	1.2391	1.3772	1.5103
27	26.21	1.0374	1.1617	1.2481	1.3851	1.5170
28	27.44	1.0473	1.1708	1.2565	1.3923	1.5231
29	28.65	1.0562	1.1790	1.2640	1.3988	1.5285
30	29.85	1.0644	1.1863	1.2708	1.4045	1.5332
31	31.08	1.0723	1.1934	1.2772	1.4099	1.5376
32	32.30	1.0797	1.2000	1.2832	1.4148	1.5416
33	33.51	1.0864	1.2060	1.2886	1.4193	1.5451
34	34.73	1.0928	1.2116	1.2936	1.4234	1.5484
35	35.94	1.0987	1.2168	1.2982	1.4271	1.5513
36	37.16	1.1044	1.2217	1.3026	1.4306	1.5540
37	38.37	1.1096	1.2262	1.3066	1.4338	1.5564
38	39.59	1.1145	1.2305	1.3103	1.4367	1.5586
39	40.82	1.1193	1.2345	1.3139	1.4395	1.5607
40	42.03	1.1236	1.2382	1.3172	1.4420	1.5625
41	43.10	1.1269	1.2410	1.3195	1.4438	1.5638
41	44.31	1.1369	1.2500	1.3277	1.4505	1.5690
41	45.53	1.1517	1.2642	1.3410	1.4621	1.5786
41	46.74	1.1691	1.2816	1.3580	1.4777	1.5922
41	47.96	1.1880	1.3011	1.3776	1.4965	1.6095
41	49.17	1.2069	1.3213	1.3982	1.5170	1.6291
41	49.50	1.2120	1.3268	1.4038	1.5228	1.6347

Table II: (cont'd) (UPPER - $\tilde{\theta}_{\gamma,t}$)

UPPER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN II d = 1.5 ALPHA = BETA = 0.20

NUMBER OF FAILURES	TOTAL TEST TIME t	γ = .50	γ = .30	γ = .20	γ = .10	γ = .05
3	.24	.0898	.1254	.1563	.2178	.2935
4	1.46	.3981	.5291	.6369	.8389	1.0720
5	2.67	.5831	.7537	.8902	1.1394	1.4185
6	3.90	.7133	.9040	1.0538	1.3224	1.6179
7	5.12	.8075	1.0081	1.1638	1.4395	1.7392
8	6.33	.8783	1.0837	1.2415	1.5186	1.8173
9	7.55	.9347	1.1420	1.3000	1.5758	1.8715
10	8.76	.9794	1.1869	1.3442	1.6174	1.9093
11	9.98	1.0165	1.2232	1.3792	1.6492	1.9370
12	11.19	1.0468	1.2522	1.4066	1.6732	1.9572
13	12.41	1.0725	1.2762	1.4289	1.6922	1.9726
14	13.62	1.0938	1.2958	1.4468	1.7070	1.9840
15	14.84	1.1122	1.3123	1.4617	1.7188	1.9929
16	16.05	1.1277	1.3260	1.4738	1.7282	1.9996
17	17.28	1.1413	1.3379	1.4842	1.7360	2.0050
18	18.50	1.1530	1.3479	1.4928	1.7422	2.0092
19	18.78	1.1536	1.3483	1.4932	1.7425	2.0093
19	19.99	1.1675	1.3604	1.5035	1.7499	2.0142
19	21.21	1.1937	1.3854	1.5266	1.7686	2.0277
19	21.90	1.2109	1.4029	1.5436	1.7833	2.0392

MIL-STD-781C TEST PLAN III d = 2.0 ALPHA = BETA = 0.10

NUMBER OF FAILURES	TOTAL TEST TIME t	γ = .50	γ = .30	γ = .20	γ = .10	γ = .05
3	.70	.2618	.3658	.4560	.6352	.8561
4	2.08	.5724	.7631	.9208	1.2184	1.5650
5	3.48	.7696	.9986	1.1831	1.5226	1.9075
6	4.40	.8403	1.0760	1.2643	1.6079	1.9949
6	4.86	.9027	1.1491	1.3444	1.6982	2.0930
7	5.79	.9535	1.2023	1.3984	1.7519	2.1450
7	6.24	.9998	1.2542	1.4535	1.8106	2.2052
8	7.18	1.0383	1.2931	1.4918	1.8469	2.2385
8	7.63	1.0746	1.3322	1.5321	1.8878	2.2783
9	8.56	1.1037	1.3606	1.5594	1.9125	2.2999
9	9.02	1.1332	1.3913	1.5902	1.9423	2.3275
10	9.94	1.1556	1.4125	1.6102	1.9597	2.3419
10	10.40	1.1793	1.4364	1.6336	1.9814	2.3610
11	11.34	1.1980	1.4536	1.6495	1.9946	2.3715
11	11.79	1.2170	1.4724	1.6674	2.0106	2.3849
12	12.72	1.2319	1.4857	1.6795	2.0203	2.3923
12	13.18	1.2479	1.5011	1.6939	2.0326	2.4021
13	14.10	1.2599	1.5116	1.7032	2.0398	2.4073
13	14.56	1.2731	1.5239	1.7146	2.0491	2.4144
14	15.49	1.2831	1.5326	1.7221	2.0547	2.4183
14	15.94	1.2939	1.5425	1.7310	2.0617	2.4234
15	16.88	1.3025	1.5497	1.7371	2.0661	2.4263
15	17.34	1.3118	1.5581	1.7445	2.0718	2.4302
16	18.26	1.3187	1.5638	1.7493	2.0751	2.4323
16	19.65	1.3484	1.5911	1.7739	2.0940	2.4453
16	20.60	1.3755	1.6184	1.7999	2.1161	2.4620

Table II: (cont'd) (UPPER - $\tilde{\theta}_{\gamma,t}$)

UPPER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN IV $n = 2.0$ ALPHA = BETA = 0.20

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
2	.70	.4171	.6379	.8491	1.3163	1.9698
3	2.08	.8127	1.1549	1.4606	2.0916	2.9133
4	2.80	.8914	1.2418	1.5517	2.1863	3.0078
4	3.46	1.0284	1.4084	1.7379	2.3998	3.2402
5	4.18	1.0734	1.4541	1.7830	2.4418	3.2774
5	4.86	1.1634	1.5551	1.8891	2.5506	3.3819
6	5.58	1.1910	1.5816	1.9139	2.5716	3.3986
6	6.24	1.2478	1.6413	1.9733	2.6267	3.4455
7	6.96	1.2654	1.6573	1.9876	2.6377	3.4533
7	7.62	1.3031	1.6948	2.0232	2.6677	3.4759
8	8.34	1.3147	1.7049	2.0318	2.6737	3.4797
8	9.74	1.3763	1.7664	2.0895	2.7203	3.5124

UPPER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN V $n = 3.0$ ALPHA = BETA = 0.10

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
2	.57	.3396	.5194	.6914	1.0718	1.6040
3	2.22	.8514	1.2013	1.5104	2.1387	2.9405
4	3.75	1.0993	1.4966	1.8373	2.5110	3.3478
4	3.87	1.1275	1.5322	1.8783	2.5609	3.4057
5	5.40	1.2816	1.7020	2.0557	2.7434	3.5848
5	5.52	1.3007	1.7245	2.0802	2.7703	3.6129
6	7.05	1.4030	1.8304	2.1855	2.8695	3.7010
6	7.17	1.4164	1.8451	2.2009	2.8850	3.7155
7	8.70	1.4866	1.9142	2.2666	2.9421	3.7614
7	10.35	1.6326	2.0766	2.4352	3.1097	3.9145

UPPER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN VI $n = 3.0$ ALPHA = BETA = 0.20

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
2	.36	.2145	.3281	.4367	.6769	1.0130
3	2.67	1.0053	1.4085	1.7602	2.4631	3.3386
3	4.32	1.5801	2.2143	2.7655	3.8626	5.2207
3	4.50	1.6344	2.2915	2.8625	3.9987	5.4047

Table II: (cont'd) (UPPER - $\tilde{\theta}_{\gamma,t}$)

UPPER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN VII D = 1.5 ALPHA = BETA = 0.30

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
3	1.22	.4562	.6375	.7948	1.1070	1.4920
4	2.43	.6856	.9211	1.1183	1.4961	1.9450
5	3.15	.7501	.9921	1.1927	1.5743	2.0247
5	3.65	.8322	1.0898	1.3009	1.6974	2.1594
6	4.37	.8743	1.1335	1.3448	1.7402	2.1998
6	5.58	1.0323	1.3164	1.5430	1.9578	2.4286
6	6.80	1.2142	1.5387	1.7939	2.2533	2.7633

UPPER CONFIDENCE LIMITS FOR THETA ON THE REJECTION BOUNDARY

MIL-STD-781C TEST PLAN VIII D = 2.0 ALPHA = BETA = 0.30

NUMBER OF FAILURES	TOTAL TEST TIME t	γ=.50	γ=.30	γ=.20	γ=.10	γ=.05
3	1.72	.6432	.8987	1.1205	1.5607	2.1035
3	3.10	1.1121	1.5594	1.9473	2.7171	3.6659
3	4.50	1.3867	1.9710	2.4763	3.4779	4.7114

Table II: (cont'd) (UPPER - $\tilde{\theta}_{\gamma,t}$)

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This paper presents tables for confidence limits on the MTBF of an exponential distribution using observations from sequential tests of MIL-STD 781. An example shows the use of the tables. The theory and calculation of the tables are explained in the Appendices.

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